Improving the Effective Resolution of Passive Microwave Precipitation Retrieval: Global and Regional Diagnostics over Land and Oceans

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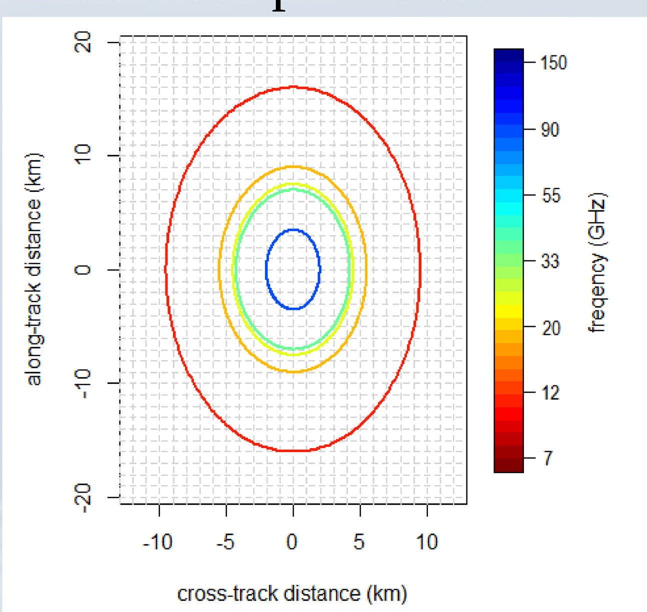
Introduction: instrumental resolution, grid spacing and effective resolution of the final product

- Satellite precipitation retrieval products are generally gridded products with regular or irregular grid increment.
- While the grid spacing is often referred as the "resolution" of the product it does not ensure the ability to resolve precipitation patterns at the corresponding scale.
- Even if grid spacing generally depends on instruments' resolution it may also be partially arbitrary, in particular for multispectral retrievals and multisensor products.



Footprint of GMI
The size of the footprint depends on the frequency, making it difficult to define the resolution of GMI-based precipitation retrievals such as GPROF.

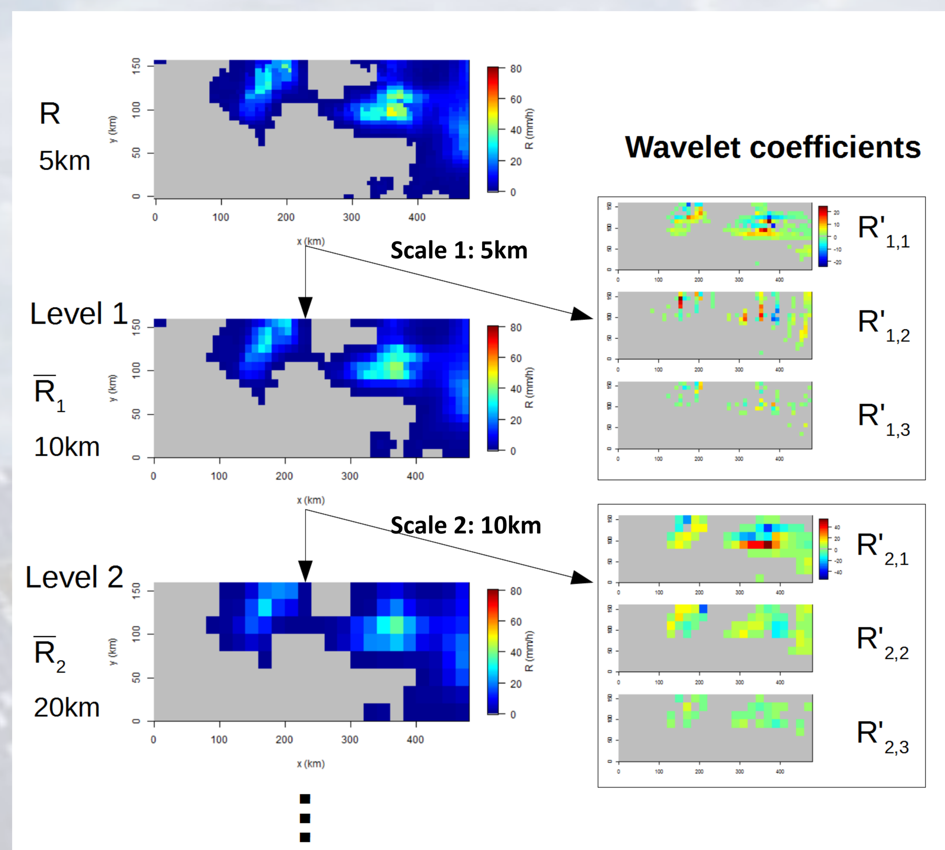
- We define the "effective resolution" of a product, as the finest scale at which it is able to correctly reproduce precipitation patterns. The effective resolution does not only depend on the instrumental resolution and shall be systematically assessed.

Wavelet decomposition: a diagnostic tool to properly define the effective resolution

The discrete wavelet transform decomposes the precipitation field *R(x,y)* into a series of wavelet coefficients $R'_{\lambda,i}$ encoding the variations of R at various scales. It is an orthogonal decomposition, the wavelet coefficients are not spatially correlated and not correlated across scales. To compare two fields R_a and R_b in the wavelet domain one can consider:

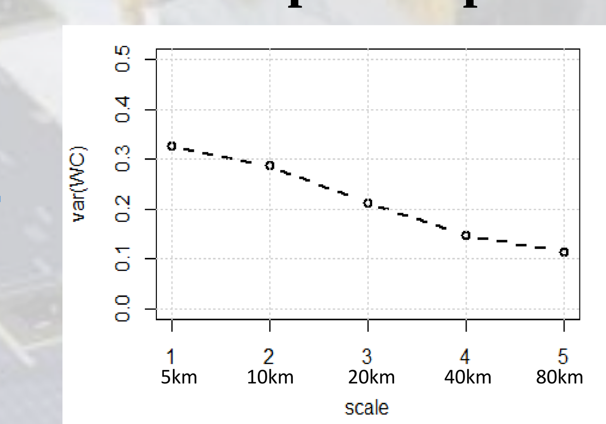
- The variance of the wavelet coefficients at each scale (wavelet spectrum).
- The wavelet spectrum of the error field $R_a - R_b$.
- The covariance / correlation of the wavelet coefficients R'_a and R'_b at each scale.

If R_a is evaluated against the reference R_b, the effective resolution of R_a is the finest scale which for R'_a and R'_b are consistent. Here we use as a criterion $\cos^2(R'_a, R'_b) > 0.5$



The wavelet spectrum shows the contribution of each scale to the total variance of the field.

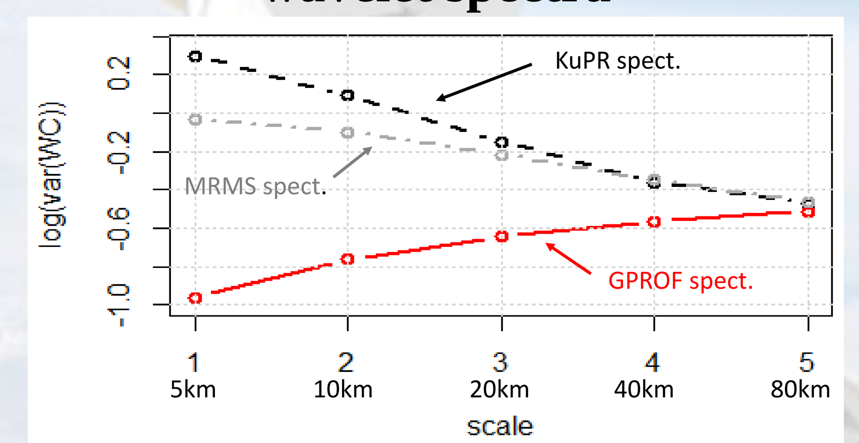
2D wavelet power spectrum



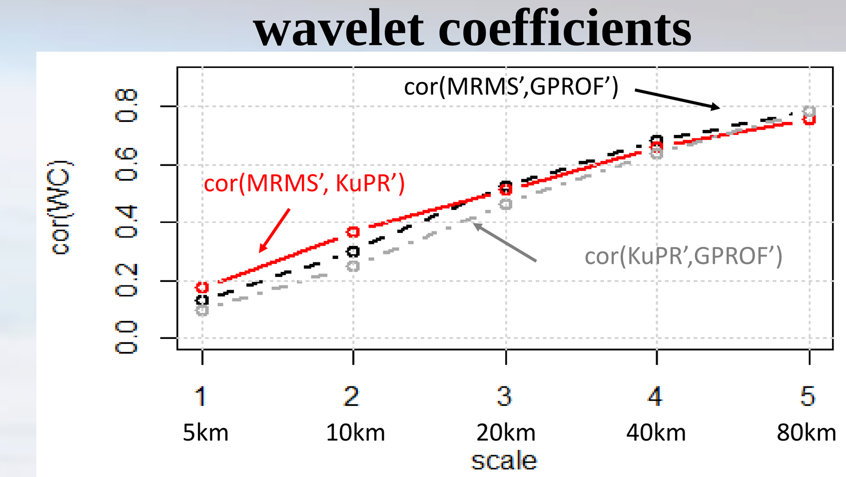
GPROF and KuPR compared to MRMS

Comparison with MRMS radar product over continental US in 2015 and 2016. 1675 GPM overpasses.

wavelet spectra



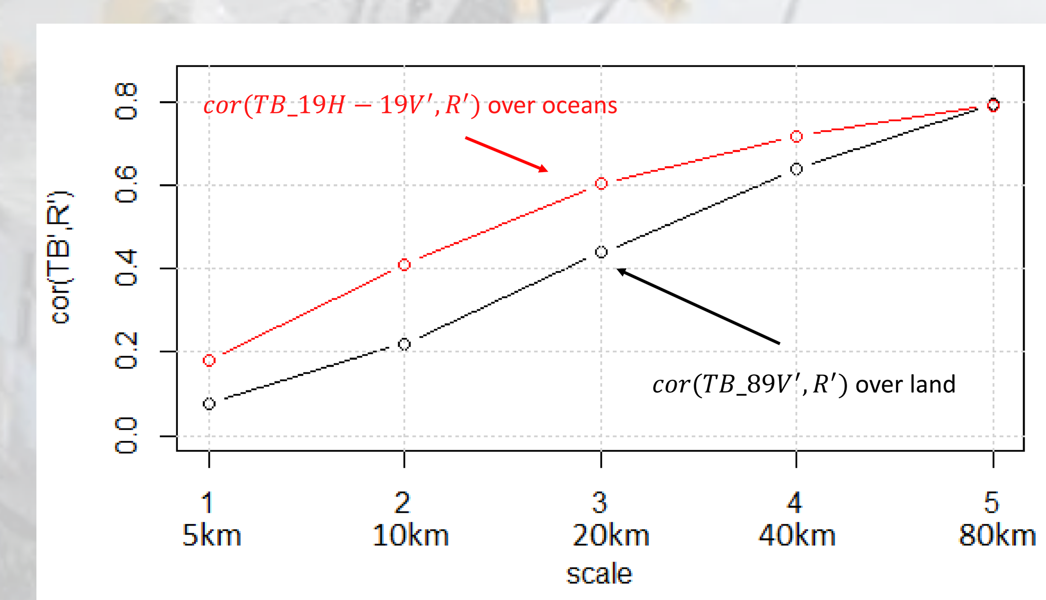
correlation of the wavelet coefficients



=> MRMS smoother than KuPR.
=> GPROF closer to MRMS than to KuPR.

Information content of the various GMI channels

- Analysis of the joint variations of GMI TBs (19GHz and 89GHz) and KuPR rain rates.

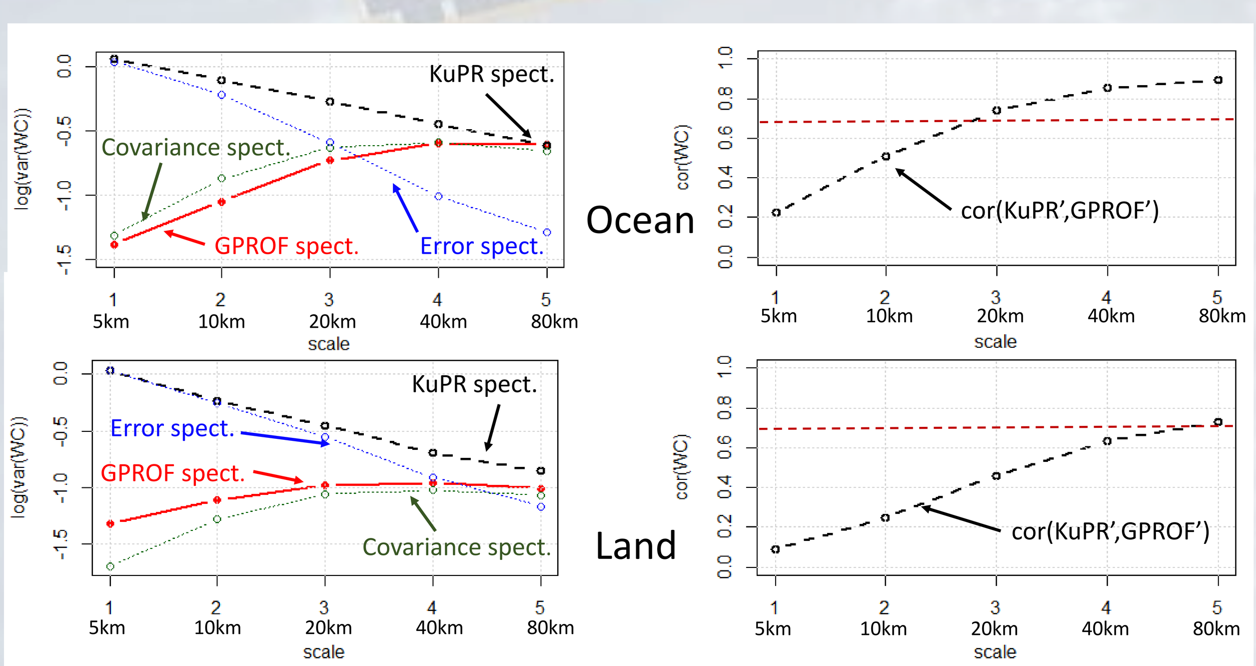


=> The coarse-scale spatial variations of $TB_{19H-19V}$ are linearly correlated with the spatial variations of R over oceans.

=> The coarse-scale spatial variations of TB_{89V} are linearly correlated with the spatial variations of R over land, but the correlation decreases fast with scale.

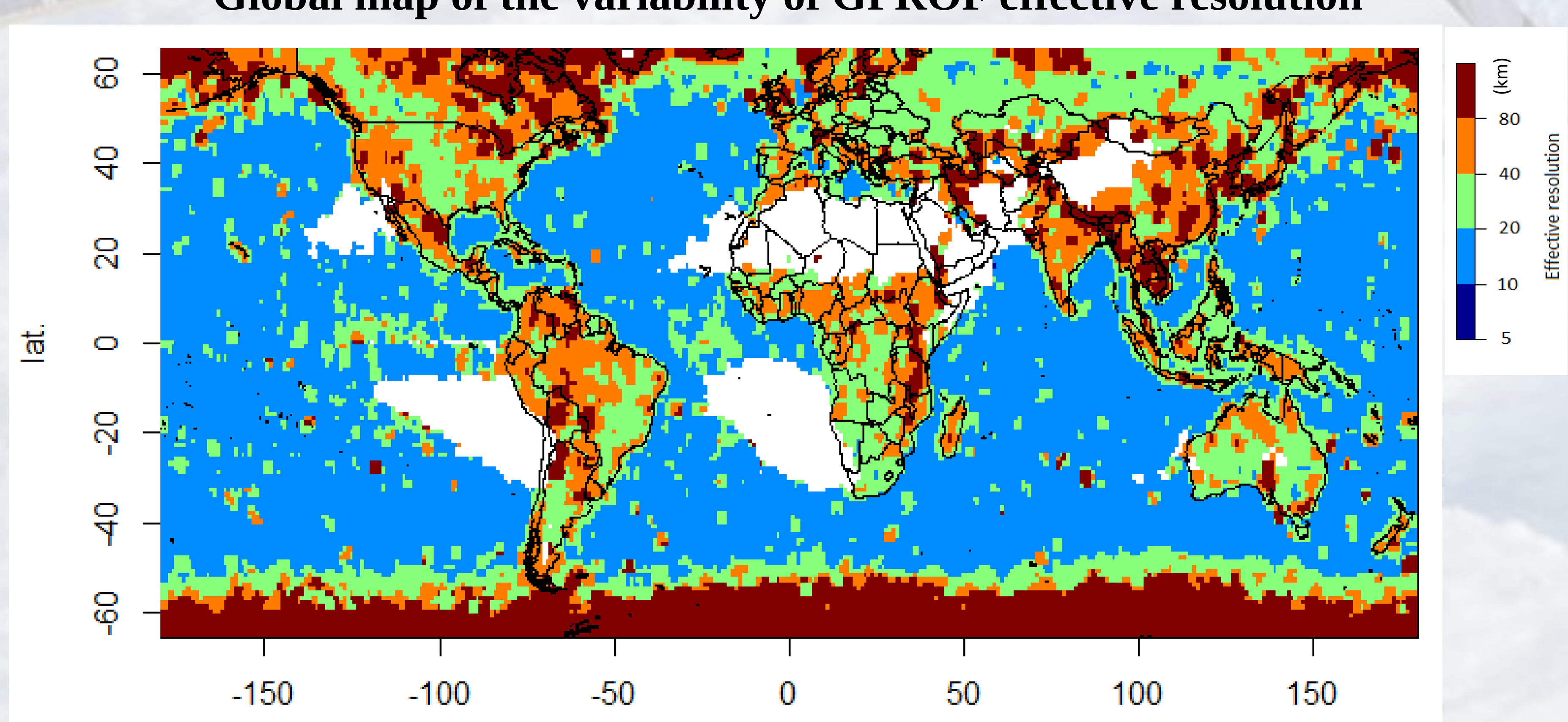
Global comparison of GMI GPROF-2017 retrievals with KuPR fields

Three years of collocated GMI and KuPR observations, March 2014 to February 2017, 16500 GPM orbits.



wavelet spectra **correlation of the wavelet coefficients**

Global map of the variability of GPROF effective resolution



=> GPROF is a smooth estimate (lacks variance at fine scales).
=> Effective resolution: 10~20km over oceans 40~80km over land.

Conclusions and perspectives:

- GMI GPROF-2017 can better resolve fine-scale precipitation patterns over oceans than over land.
- In spite of their coarser resolution, the low frequency channels of GMI (19H and 19V) which are sensitive to rain drops emission signal seems to contain more information about the fine-scale variability of surface precipitation than the better resolved high-frequency channel (89V).
- Complex ground emissivity makes the interpretation of low frequency channels ambiguous over land. Therefore, over land most of the exploitable information comes from the high frequency channels.
- The high frequency channels are sensitive to ice scattering. Future work will determine down to which scale the ice content of the clouds can accurately predict surface precipitation patterns.

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References: Guilloteau, C., Foufoula-Georgiou, E., and Kummerow, C. D., 2017: Global multiscale evaluation of satellite passive microwave retrieval of precipitation during the TRMM and GPM eras: effective resolution and regional diagnostics for future algorithm development. *Journal of Hydrometeorology*, doi:10.1175/JHM-D-17-0087.1